While the organism does not pass the endodermis, its influence upon the hypertrophy of the tissues extends to the endodermis and the tissue of the central cylinder on that side.

(*To be continued.*)

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The genus Corallorhiza.

M. B. THOMAS.

WITH PLATES XVI AND XVII.

The genus Corallorhiza contains twelve recognized and well defined species with widely varying habitat, being found in Europe, Asia, United States and Mexico.

Four species are found in Northern United States; *Corallorhiza innata* R. Brown, *C. odontorhiza* Nutt., *C. multiflora* Nutt. and *C. striata* Lindl. Of these C. multiflora has the widest range and is the one found in greatest abundance.

The parts above ground have been quite thoroughly studied and the structure is generally well understood, but the parts below ground certainly afford an opportunity for much profitable investigation. The plants of the genus are brownish or yellowish herbs, without chlorophyll, except a little late in life, and in C. multiflora they often reach the height of eighteen inches.

The parts underground are usually described as being "much branched and toothed coral-like root-stocks (probably root parasitic) sending up a simple scape, with sheath in place of leaves, and bearing a raceme of rather small, dull-colored flowers."[1] From the rather striking characters of the stem and flowers it might be expected that the plant would exhibit several marked deviations from the regular phenomena of growth and development, and such is indeed the case. The coralline root-stock which the plant possesses has many variations from the regular type of the underground stem of monocotyledonous plants. The vascular system is represented by somewhat modified collateral bundles which are confined to the center of the stem; these are small and usually quite rudimentary. The whole vascular system is

[1]Gray's Manual, 6th edition.

surrounded by a sheath of collenchyma which gives the fibro-vascular tissues somewhat the appearance of the radial bundles of roots. The arrangement of bundles inside the sheath is as one might expect, usually irregular, but in each individual bundle the phloem occupies the peripheral side.

At the apex of the stem we find about the normal arrangement of parts. The leaves originate near the apex as lateral outgrowths in acropetal order. The primary meristem of the growing point is very active and several immature leaves with those just forming cover the apex.

The tissue of the leaf is perfectly continuous with that of the stem. The foliar bundles are very small and merely pass up to the base of the leaf, which undergoes no differentiation but simply breaks away and there remains a ring or scar in its place on the stem. In the depressions between these rings are found papillæ, which, on the average, are 0.2^{mm} high, and 0.6^{mm} in diameter. On these are borne the trichomes, which are often longer than the height of the papillæ. By means of these papillæ the root may cling tenaciously to any substance with which it may be in contact. Trichomes are often developed on the portions of the leaf-scars that may remain attached to the stem. They are quite large, thin walled, and contain protoplasm with a very large nucleus.

The plant is said to be a parasite, but the weight of evidence seems to strongly contradict such a supposition. Although by means of these trichomes the plant may cling to the roots of other plants, yet repeated search has failed to show any organic connection with them. The epidermis of the root-stock is much broken up by the numerous leaf scars and papillæ but it presents the ordinary characters of a true epidermis. The cortex is of the usual nature and contains many large cells with raphides. It may be possible that the plant does derive some of its nourishment from the roots of other plants to which it clings by means of its papillæ with their trichomes, yet these papillæ are found equally on all parts of the root-stock, and that too on plants which are in no way connected with any other living plant; while those grown in a jar of ordinary soil, free from the roots of all other plants, thrive equally well with those in the woods.

The question at once presents itself, how does the plant elaborate its fluid without the intervention of chlorophyll, especially since in the autumn there is a ring of cortical tissue about the fibro-vascular system the cells of which are filled with starch, while the remainder of the cortex toward the epidermis contains a considerable quantity of it.

When first studying these stems it was observed that the cell contents of the cortical tissue stained a *dark* purple with hæmatoxylin and often a brownish hue was secured. As this did not represent the usual reaction, it seemed that something extraordinary existed in the cells, and upon further examination it was seen that their cell contents consisted of a small mass of protoplasm completely surrounded and permeated by a great number of septate hyphal threads and these were often traced to similar ones outside of the stem. The latter were somewhat larger and always presented a much denser structure. At first it seemed that the threads might be accidental and due to the presence of some parasite that had attacked the individual plant, but later they were found in the stems of plants obtained from various parts of the country.

The hyphæ are confined to a certain region of the stem and are seldom found within 3–4^{mm} of the tip. The cells nearest the tip, in which they first appear, contain but a few, and it is here that their structure can be best studied. Farther back from the tip the threads increase in abundance in the cells and become very much smaller until they seem to be finally absorbed by the cell protoplasm. The whole assemblage then assumes a granular character and forms with the original cell contents a homogeneous mass. The action of the nucleus is very certain as it responds to the presence of these threads by enlarging, and thus showing an increase in the activity of the cell. Very few of the threads are ever found in the epidermal layer, but they pass through this into the cortex beneath. The few that are in the epidermal tissue partake of the nature of those outside, while just beneath a marked difference is seen.

With a magnification of 2,000 diameters the threads are seen to be a cylindrical tube with walls of a distinctly laminated structure, septate and the outer surface in many cases covered with protuberances. The central cavity of the thread is filled with filamentous masses of protoplasm of a granular character. The hyphæ branch freely and often seem to radiate from a common center which may be the nucleus of the cell.

The cell walls are pierced readily and the threads can be traced through several rows of cells. In proportion to the number of hyphæ present the walls are little punctured as the great mass of threads is confined to the interior of the cell and they are seldom found in the intercellular spaces. The tissue of the stem is most thoroughly permeated with these hyphæ, and every cell outside of a narrow zone around the plerome, which so often contains starch, and back 2–3^{mm} from the tip, is filled with them. The tissue exhibits nothing that would in any way seem to indicate that the presence of these hyphæ was anything other than beneficial and there can be no doubt of there existing a true symbiotic relation.

The large amount of starch often found in the rootstock cannot be due to the decomposition of CO_2, for chlorophyll is wanting; but it is a derivative of those chemical compounds which have been dissolved and taken up by the hyphæ from the remains of dead plants. The ash constituents and some of the nitrogen compounds may be taken up from the soil by the trichomes and the nitrogen used in the formation of proteid substances for the plant, while the trichomes in contact with old leaves and other humus substances no doubt secrete a ferment and absorb the products which are in solution. This action with the symbiotic relation existing in the plant would give it two methods of obtaining plant food. From the structure of the plant and the abundance of the hyphæ the latter condition must furnish it its greatest source of supply.

Instead of being a root parasite, as has been supposed, the plant depends chiefly on the symbiotic condition for its food and this is taken by the hyphæ from the decaying vegetable matter about. If the plant was once a true parasite the roots have degenerated and finally disappeared, for no roots are found on the plant. This condition exists in an equal degree in all of the species of Corallorhiza yet examined.

It should be stated, however, that hyphæ have been found in the roots of all of our North American Orchidaceæ yet examined (more than forty species), but only in a very limited degree, apparently not enough to materially affect the normal conditions of growth and development; although some varying conditions due to the presence of these relations have been observed, which are constant through the whole group. Endotrophic mycorhiza that pass their whole life course in the part of the plant below ground do no doubt exist in all of the Orchidaceæ. The genus Corallorhiza, in the abundance of this condition, is far removed from the other members of this order.

It is not necessary to give a complete bibliography of the work done on the subject of symbiosis. References to the more important articles can be found in the paper of A. Schneider.[2] The principal papers of B. Frank, who has no doubt done more than any other observer on this subject, can be found in the Berichte der deutschen botanischen Gesellschaft, 1890, 1891, and 1892.

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EXPLANATION OF PLATES XVI AND XVII.

Figs. 1, 2. Base of aerial and subterranean stems of *Corallorhiza innata* R. Br.

Figs. 3-9. From *Corallorhiza multiflora* Nutt.

Fig. 3. Base of aerial and subterranean stems. Fig. 4. Longisection of root-stock; *a*, old leaf not yet broken away; *b*, *c*, remains of leaves that have broken away; *d*, papilla with trichomes, *g*; *e*, axial bundle; *f*, large cells containing raphides. × 480. Fig. 5. Cells of cortical tissue, with hyphæ, taken from the tip of the stem where they contain but few hyphæ; *a*, enlarged nucleus. Fig. 6. One of the rudimentary bundles of the stem; *a*, general bundle sheath; *b*, xylem; *c*, phloem; *d*, fundamental tissue. × 750. Fig. 7. Remains of a leaf, *a*, with trichom s, *b*. × 750. Fig. 8. Papilla, *a*, with trichomes, *b*. × 750. Fig. 9. Transection of root-stock; *a*, papilla with trichomes; *b*, cell with raphides; *c*, general bundle sheath; *d*, collateral fibro-vascular bundle with an unusually regular arrangement. × 480.

George Vasey: a biographical sketch.

WM. M. CANBY AND J. N. ROSE.[1]

WITH PORTRAIT—PLATE XVIII.

On the first of April, 1872, Dr. George Vasey was appointed Botanist to the Department of Agriculture. For twenty-one years he continuously held this position with credit to himself as well as to the advantage and satisfaction of the government and of his botanical confreres. The life of one who could do this during this time of great botanical activity and advancement must present interesting points to all who are engaged in the study of botany; and it is to satisfy this interest that these notes are written.

[2]Bull. Torr. Bot. Club, XIX, 216.

[1]It is proper to state here that Dr. Vasey had requested Mr. Canby to prepare a sketch of his life and the Editors of the GAZETTE not knowing of this request asked me to gather together what data I could regarding his life. At Mr. Canby's suggestion this article is published jointly as it avoids much duplication. My relations with Dr. Vasey, while most intimate, only extend back to 1888, whereas Mr. Canby has enjoyed an acquaintanceship and correspondence of more than 30 years.—J. N. R.